Fundamentals & Basics of MMAW

1.0 INTRODUCTION:

Among the arc welding processes, Manual metal arc welding (MMAW) or Shielded metal arc welding (SMAW) is most common, versatile and inexpensive. The electrode melts in the weld arc and gets deposited on the adjoining surface. MMAW process accounts almost 80% of the total welding in India. It is suitable for any range of plate thickness and can be used for all commercial metal & alloys.

The process comprises of a Power source, MMAW electrode and the connecting cables (as shown in figure-1). SMAW electrodes are available in a wide range of diameters. Generally for all commercial fabrication, the diameter of the electrodes lies between 1.6 to 6.3mm, considering the thickness of the plate. The welding operation is schematically shown in figure-2.

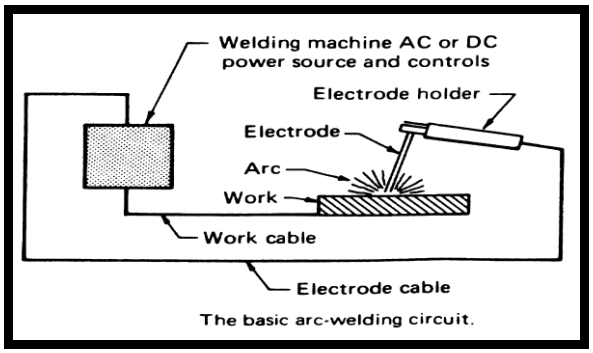

Figure-1: Schematic line diagram representation of MMAW process

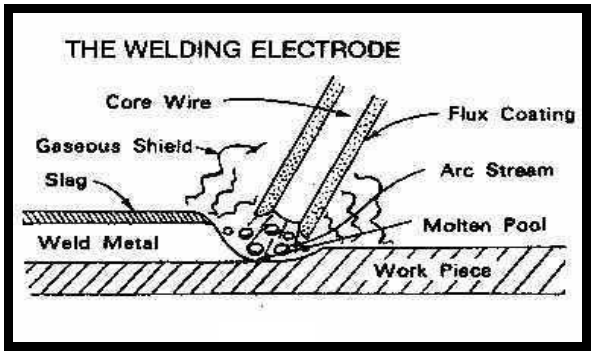

Figure-2: Schematic sketch of burning of MMAW electrodes

2.0 FUNCTIONS OF FLUX COATING:

SWAW electrode comprises of two components - the core wire and the outer flux coating. While the arc protection is the primary function of the flux coating, it has lot of other functions to do.

1. Produces slag after melting which further protects the molten weld metal from oxidation.
2. Stabilizes the arc during welding and helps to work in different welding positions.
3. Provides a mean to add iron powders for high deposition efficiency electrode.

4. Helps to deoxidize and refine the weld metal.
5. Provides alloying to achieve alloy steel weld metal.

3.0 ABOUT THE OPERATION OF MMAW PROCESS:

For the ease of understanding, the basic working in MMA welding can be divided into various steps. We will discuss at each of them.

3.1 Electrical connections in MMAW process – Both AC and DC power sources are used for MMAW process. The electrical connections are schematically shown in figure-1.

3.2 MMAW Power sources – Both AC and DC power sources are used for MMAW. Variation in arc length and hence arc voltage are unavoidable because of human factoring MMAW, hence power sources used are of the constant current type. This means, variation in arc voltage have little or negligible effect on the welding current.

Air-cooled transformers, oil-cooled transformers, multi-point transformers & alternators are used as AC power sources.

Common DC power sources are- motor generators, diesel generators, rectifiers (diode/ thyristorized) and inverters / choppers. The photograph of AC & DC power sources are shown in the figure-3 respectively. The current & voltage shall be adjusted through the respective knobs in the machine as per the requirement of welding.

Figure-3: Photograph of AC transformer and DC Rectifier type welding power sources.

3.3 Electrodes – Electrodes for MMAW have two components; core wire and the flux coating. The lengths are generally made in 300mm, 350mm and 450mm depending on the core wire diameter. They are grouped based on the weld metal chemistry and/or type of flux coating. For example: Carbon steel electrodes, Stainless steel electrodes, Cast iron electrodes, Nickel electrodes, etc are based on weld metal chemistry and Rutile, Basic, Cellulosic, etc are based on the type of flux coating.

3.4 Welding accessories – MMAW requires few common welding accessories which are the essential part for successful application of the process. The schematic sketches of the electrode, welding screens, clamp, cleaning wire brush, hammer are shown in figure-4 & 5.

Figure-4: Schematic sketch of electrode holder and the welding screens.

Figure-5: Sketch showing welding clamp, cleaning brush and hammer.

The cables must be rigidly fastened and a lug may be attached to the earthing end of the ground cable to connect it to the work bench as shown in the figure-6.

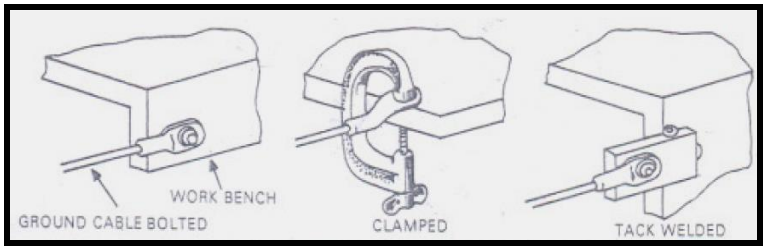

Figure-6: Method of attaching the ground cables: bolted/ clamped / tack welded.

4.0 WELDING POLARITY:

In AC welding, the choice of polarity is non-existent because AC combines reverse and straight polarity in regular cycles. Hence AC gives penetration and electrode melting rate intermediate between those given by DC+ and DC-. The comparative bead profile and penetrations are shown in figure-7.

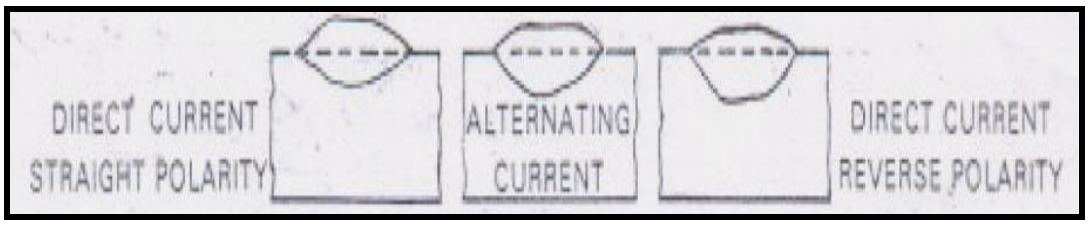

Figure-7: Comparative weld profile and depth of penetration after welding with different current conditions.

DC power sources have the advantage of working with two polarities, means that the electrode can made negative or positive. When electrode is negative it is called straight polarity (DCSP/ DCEN) and for positive terminal at electrode is called reverse polarity (DCRP/ DCEP).

5.0 OCV & DUTY CYCLE:

The voltage measured at output terminal of welding power source when welding load is not connected is called Open circuit voltage (OCV) or no load voltage. The significance of this parameter is to ensure smooth & stable arc striking properties for all types of electrodes.

Power sources are of various current ratings and are rated by the manufacturers on the basis of their current output at specific duty cycles. Duty cycle is defined as the percentage of a ten minute interval that it operates at a given current rating. A 60% duty cycle means that the arc is in action for six minutes out of a ten minute time period.

Sometimes welding machines are required to give output other than rated value. In this case, the user should know the safe current of operation at 100% duty cycle. The rated current at 100% duty cycle for a 400A 60% duty cycle machine is calculated as-

$$100 = (400 / \text{Desired current})^2 \times 60$$

Therefore, the desired current for a 400A 60% duty cycle machine at 100% duty cycle will be 310A.

6.0 CLASSIFICATION SYSTEM AS PER AWS A 5.1 STANDARD:

E XX YY M – 1 H Z R

(a) (b) (c) (d) (e) (f) (g)

(a) 'E' indicates to be used as an electrode.

(b) Indicates the minimum tensile strength of the undiluted weld metal in ksi. For example: 60, 70, 80, 90, 110, etc.

(c) Indicates welding position in which electrodes are usable, type of covering and the kind of welding current for which the electrodes are suitable, Table-1.

(d) Designates an electrode intended to meet most military requirements (greater toughness, lower moisture content, etc.)

(e) Indicates that the electrodes (E7016, E7018 & E7024) meet the requirement for improved toughness and ductility in case of E7024.

(f) Indicates the optional requirements of diffusible hydrogen in the deposited weld metal. H4, H8, H16 represents average maximum allowable diffusible hydrogen to be of 4, 8 and 16 ml/100 gm respectively.

(g) Designates that the electrode meets the requirements of the absorbed moisture test for all low hydrogen electrodes (optional) except E7018M (mandatory).

Table-1: Electrode Classifications as per AWS SFA 5.1

Classification	Type of Covering	Welding Position	Type of Current
E6010	High cellulose sodium	F,V,OH,H	dcep
E6011	High cellulose potassium	F,V,OH,H	ac or dcep
E6012	High titania sodium	F,V,OH,H	ac or dcep
E6013	High titania potassium	F,V,OH,H	ac or dcep or dcen
E6018	Low-hydrogen potassium, iron powder	F,V,OH,H	ac or dcep
E6019	Iron oxide, titania potassium	F,V,OH,H	ac or dcep or dcen
E6020	High iron oxide	H-fillet	ac or dcen
		F	ac, deep or deep
E6022	High iron oxide	F, H-Fillet	ac or dcen
E6027	High iron oxide, iron powder	H-fillet	ac or dcen
		F	ac, dcep or dcen
E7014	Iron powder, titania	F,V,OH,H	ac, dcep or dcen
E7015	Low hydrogen sodium	F,V,OH,H	dcep
E7016	Low hydrogen Potassium	F,V,OH,H	ac or dcep
E7018	Low hydrogen potassium, iron powder	F,V,OH,H	ac or dcep
E7018M	Low hydrogen iron powder	F,V,OH,H	dcep
E7024	Iron powder, titania	H-fillet, F	ac, dcep or dcen
E7027	High iron oxide, iron powder	H-fillet	ac or dcen
		F	ac, dcep or dcen
E7048	Low-hydrogen potassium, iron powder	F,OH,H,V-down	ac or dcep

7.0 COMMON MMAW ELECTRODES – E6013 & E7018 TYPE:

7.1 E6013 electrodes – E6013 class as per AWS SFA 5.1 is classified as “high titania potassium type covering” suitable for ac, dcep or dcen current working in flat, vertical, overhead & horizontal welding applications. The flux covering makes easier slag removal and smoother arc transfer in E6013 electrodes. Few of this class of electrodes are suitable for vertical down welding position also.

The salient characteristic of this class of electrodes is satisfactory operation with lower open circuit voltage (OCV). This means the electrodes operate even on a 50 OCV transformer. They are designed specifically for light sheet metal work and lower strength applications.

However, E6013 class electrodes are limited in areas where high strength, thick plate joining are required and also for jobs which may undergo dynamic loading in service.

7.2 E7018 electrodes – In E7018 class, the type of covering is classified as “low hydrogen potassium with iron powder” recommended for ac or dcep current condition. These electrodes are also known as “Low hydrogen” electrodes wherein the slag is chemically basic in nature.

They are used for joints involving high strength, high carbon and low alloy steels. The fillet welds made in the horizontal & flat welding position have a slightly convex weld face with a smooth & finely rippled surface.

Basic type MMAW electrodes deposit lower hydrogen level in the weld metal compared to rutile type electrodes. Depending on the design, the diffusible hydrogen generally lies between 3-10ml per 100 gms of weld metal. But in case of rutile type electrodes it is much higher (above 15ml/ 100 of weld metal).